SYNOPSIS

Efficacy of Dyeing and Printing Banana Cotton Blended Fabrics with *Peltophorum pterocarpum*

By

K.Sangamithirai

(Reg. No. 16PHTCP001)

Supervisor

Dr.N.Vasugi

Professor,

Department of Textiles and Clothing

School of Home Science

Dean, Student Affairs

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Avinashilingam Institute for Home Science and Higher Education for Women,

Coimbatore – 641043

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Introduction

Consciousness of ecology is increasing around the world. There is an increase in preference for natural products among the consumers. Though modern methods and development have paved the way for a sophisticated living, we have paid the price in the form of environmental pollution. This led us back to nature, which directed the textile industry to use natural fibres and natural dye. Many researchers are now focusing on developing products with natural fibres, environmentally friendly processes, sustainability and safer to eco-system. Conventional natural fibre production could not meet the demands and expectations of producers and consumers. The use of natural fibres gained wide acceptance as a result of their excellent engineering properties, which include low density, lower cost, environmental friendliness, biodegradability and ease of recycling (Narayana and Rao, 2021). A few alternative non-conventional natural fibre jute, sisal and agave are already established, but their main objective of growing these plants is producing fibre only. Banana fibre, being agricultural residue, has the advantage over other natural non-conventional fibres. India contributed 22 per cent of the global banana production (Rajput and Khot, 2022). The pseudostem is major part of banana waste biomass, which gives good quality fibres that has great demand in various industries (Badla et al., 2021).

Many researchers are working on banana fibre to produce a sustainable fabric and to make it available to our market (Ali and Karale, 2022). Though research is carried out widely in the application of banana fibre in various fields, from handicrafts, apparel, composites and the automobile industry, its potential still needs to be fully utilised. In spite of its many advantages, it is difficult to spin into a yarn due to its lignin. Surface modifications by physical methods or chemical methods tend to reduce these drawbacks (Ernest and Peter, 2022). However, the widespread use of these chemicals has resulted in a hazardous wastewater disposal problem and a significant expense and risk to employees. Hence, safer and more ecologically friendly procedures are needed to degrade the lignin of the fibre, which improves the fibre's quality (Patel and Patel, 2022).

The increase in the integrated natural fibre textile sectors for nature-friendly products may help to produce diversified and high-value eco-friendly textiles. Value addition, such as dyeing and printing to this banana fabric, may be more profitable and have prospects for

export. Natural dyes are revived as they are considered eco-friendly and obtained from renewable resources compared to synthetic dyes derived from non-renewable petroleum resources and cause pollution (Wangatia et al., 2015). India has abundant dye sources, and there is ample scope to explore and rebuild the traditional dyeing methods to meet the needs of the consumers.

Many research has been conducted to identify sources and identify the best method for extracting the standardised quality of natural dyes with maximum quantity (Sutrisna et al., 2020). *Peltophorum pterocarpum* is an attractive tree that is the source of natural dye throughout the country and is known for its beautiful yellow blossoms. The tannins in the bark can be used as dyes, giving the leather a bright yellow hue (Natarajan et al., 2023). The dye obtained from *P.pterocarpum* can be applied for dyeing and printing on fabrics.

"Think globally, act locally" is the slogan for the world textile industry (Suparna and Antony, 2016). It is imperative to adopt simpler technologies, uncomplicated eco-friendly processes and locally available sustainable sources to make feasible employment opportunities. This research focused on utilising banana fibre as an environmentally acceptable alternative for synthetic fibres and *Peltophorum pterocarpum* flowers and bark extracts for textile dyeing and printing with eco-friendly mordants and processes. This study entitled **"**Efficacy of Dyeing and Printing Banana Cotton Blended fabrics with *Peltophorum pterocarpum***"** has been undertaken to produce banana cotton blended and mixture fabrics for specific end-use.

Objectives of the study

The study comprises the following objectives.

- To elicit information on preference for home textiles and awareness of eco-friendly textiles among women.
- To extract, soften and spin banana fibre into yarn
- To weave fabrics with the spun banana and banana cotton blended yarn and pretreatment with an eco-friendly process
- To extract and optimise dye extraction from *Peltophorum pterocarpum* flowers and bark and dyeing on the woven banana blended and cotton fabric.
- To print on woven cotton and banana blended fabrics with dyes extracted from *Peltophorum pterocarpum* flowers and bark and evaluate its colour properties.

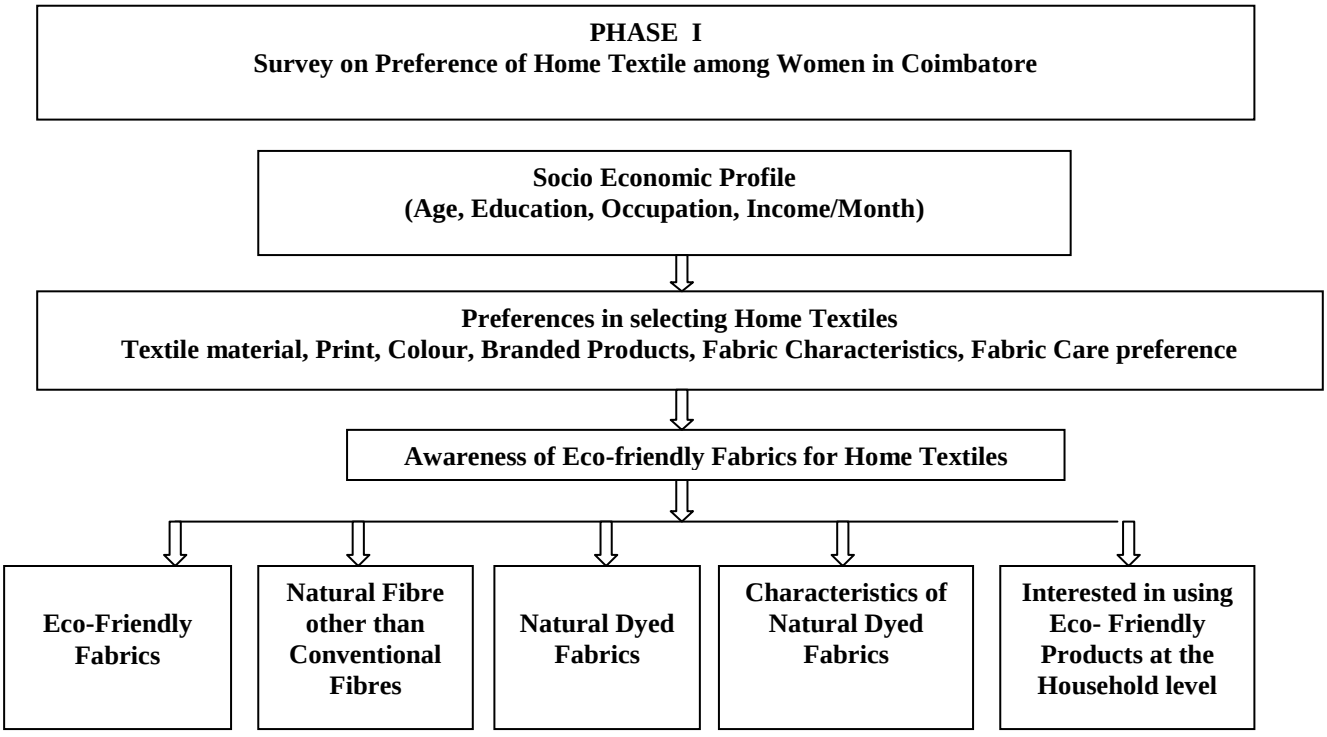
Review of Literature

The literature review for the study was carried out under the following topics.

- Natural fibres in the textile industry
- Cotton: An Overview
- Banana Fibre as natural fibre
- Natural Dyes and Mordants
- Studies on Natural Dyeing and its application
- Natural Dyes in Printing
- Overview of *Peltophorum pterocarpum*

Methodology

The methodology comprises five phases and is presented in the Flow charts below.


PHASE I
Survey on Preference of Home Textile among Women in Coimbatore
Socio Economic Profile
(Age, Education, Occupation, Income/Month)
Preferences in selecting Home Textiles
Textile material, Print, Colour, Branded Products, Fabric Characteristics, Fabric Care preference
Awareness of Eco-friendly Fabrics for Home Textiles
Eco-Friendly Fabrics
Natural Fibre other than Conventional Fibres
Natural Dyed Fabrics
Characteristics of Natural Dyed Fabrics
Interested in using Eco- Friendly Products at the Household level

PHASE II
Extraction, Softening and Spinning of Banana Fibres

Extraction of Banana Fibres

Selection of softening agent for Banana Fibres

Castor Oil | **Glycerin** | **NaOH**

Evaluation of Softened Fibres

Softening banana fibre using Castor Oil

Spinning of BananaYarn

Hand Spun Banana Yarn (100% banana yarn)

Rotor Spun Banana Cotton Blended yarn (Banana -40 % & Cotton -60%)

Evaluation of Spun banana and banana cotton blended yarn

PHASE III
Fabric Weaving and Pretreatments

Weaving

Handloom | **Powerloom**

Fabric 1- F1 C/B
Warp- 100% cotton yarn
Weft- 100% Banana Yarn

Fabric 2- F2 C / CB
Warp- 100% cotton yarn
Weft- Banana: Cotton (40: 60) Blended Yarn

Fabric 3 – F3 CB /CB
Warp & Weft-
Banana: Cotton (40:60) Blended Yarn

Pretreatment of Woven Fabrics

Cotton Fabric - C
100 % cotton Fabric

Fabric 1-F1- C/B

Fabric 2 - F2 C/ CB

Fabric 3 -F3- CB/CB

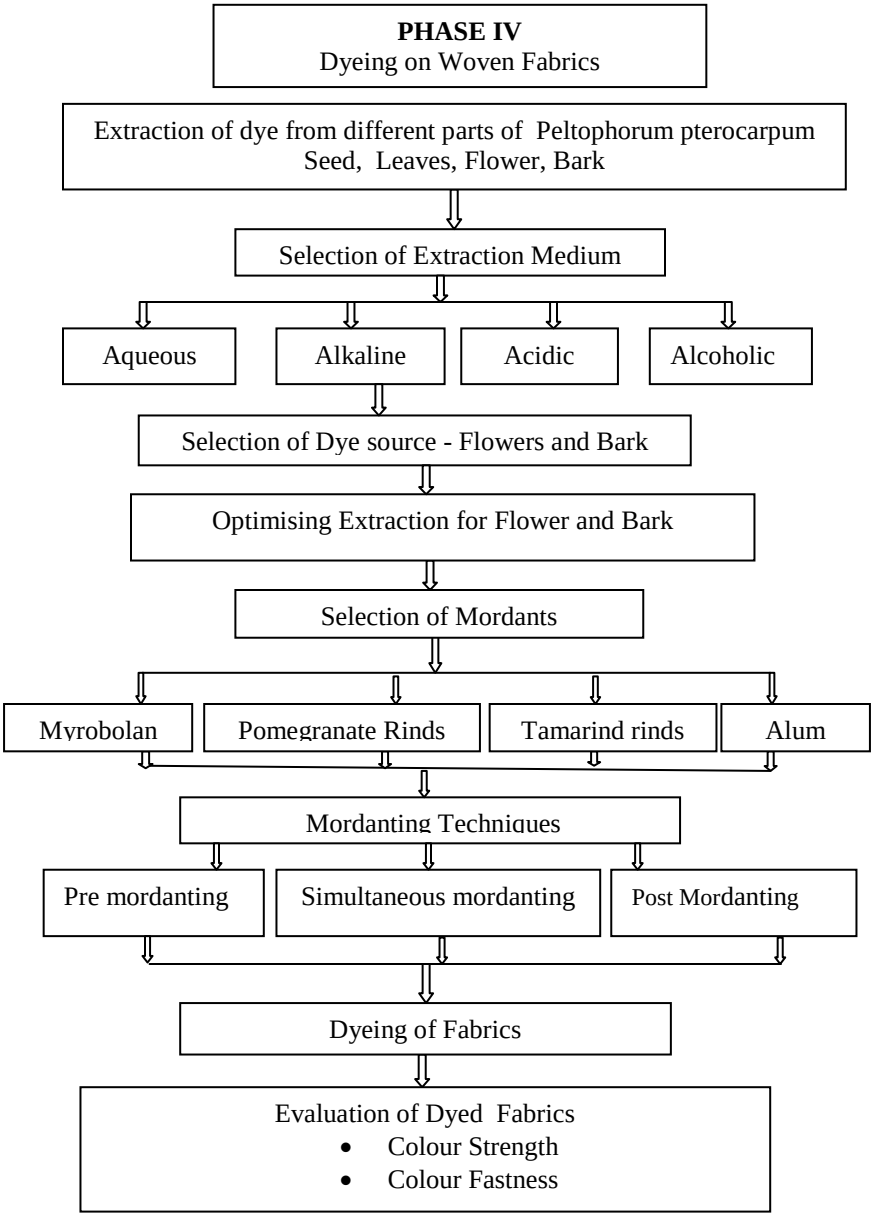
Desizing
Boiling in Non-Ionic detergent solution

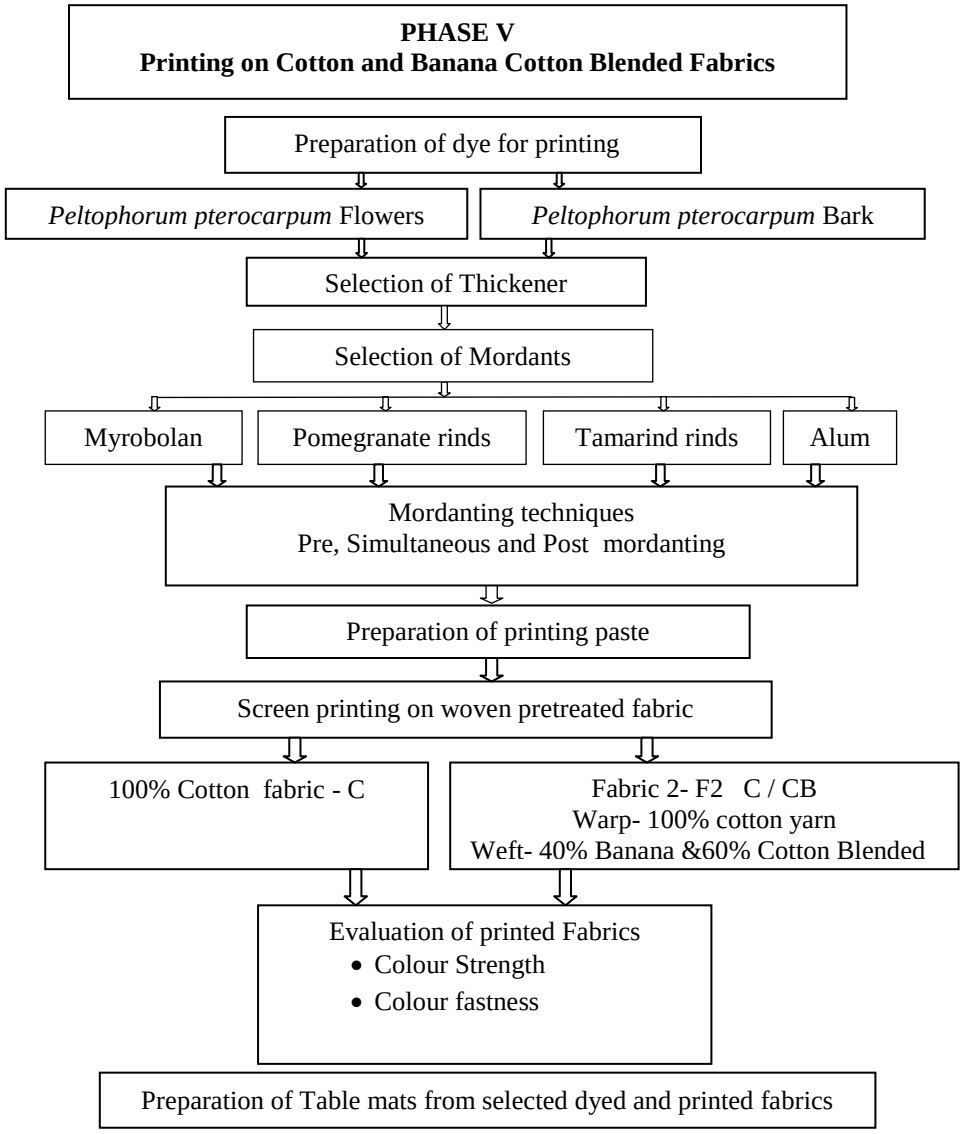
Scouring
Solution made with Cow dung- 2 kg/50 litres of water

Bleaching
Solution of Buttermilk (Buttermilk:water-50:50)

Evaluation of Grey and Pretreated Fabrics

- Fabric Weight
- Fabric Count
- Fabric Thickness
- Fabric Strength and Elongation
- Fabric Absorbency


PHASE IV
Dyeing on Woven Fabrics
Extraction of dye from different parts of Peltophorum pterocarpum
Seed, Leaves, Flower, Bark
Selection of Extraction Medium
Aqueous
Alkaline
Acidic
Alcoholic
Selection of Dye source - Flowers and Bark
Optimising Extraction for Flower and Bark
Selection of Mordants
Myrobolan
Pomegranate Rinds
Tamarind rinds
Alum
Mordanting Techniques
Pre mordanting
Simultaneous mordanting
Post Mordanting
Dyeing of Fabrics
Evaluation of Dyed Fabrics
Colour Strength
Colour Fastness



Methodology

Phase I: Survey on Preferences for Home Textiles

A survey was carried out to identify the customers' preference for home textile materials and their awareness of eco-friendly textile materials. This was conducted to get an insight into preference in design, cost, material and colour factors used in home textiles by the selected 300 homemakers in Coimbatore. A specially designed questionnaire was framed with 25 questions related to respondents' socio-economical profile, types of home textiles commonly used, material selection, care and maintenance, preference of branded products and cost. Data related to consumers' awareness of eco-friendly textiles and their willingness to use them for home textiles was gathered. A convenient sampling method was adopted to

collect the required data from the selected 300 homemakers and employed women in and around Coimbatore. The data collected were analysed for their awareness and interest in using eco-friendly textiles.

Phase II: Extraction, Softening and Spinning of banana fibres

Natural fibres are gaining importance for their low cost, less tool wear during the process, environmental friendliness and biodegradability. *Musa acuminate* species are mostly consumed by humans as fruit. In banana plantations, after the fruits are harvested, the discarded trunks or stems provide obtainable sources of fibre (Ali and Karale, 2022). Fibres extracted from banana pseudo stem have been used for making ropes, cordages, fancy rugs and home furnishings, and the cultivation have reported to have no negative effect on the environment as stated by Soraisham et al., (2021).

Considering those factors banana fiber was selected for the study. Banana fibres were extracted by hand as suggested by Sucharita and Vasugi, (2017). The extracted fibres were than cleaned, dried and softened for further processing into yarn. The lignin can be removed by boiling in optimum NaOH solution to make it suitable for spinning opined Vishnu vardhini et al., (2016). The banana fibers were treated with a number of softeners like castor oil, glycerine and Turkey Red oil for imparting a soft and supple feel to them in simple processes states Balan (2010). To finalise the softening agent a pilot study was conducted using 5% of castor oil, glycerin and sodium hydroxide each separately on banana fibres in material liquor ratio of 1:20. The treated fibres were then evaluated to compare the properties such as strength, fineness and tenacity. The morphological changes on the surface of raw and treated banana fibres were observed using Fusion Emission scanning electron microscope. Among the softening materials used, castor oil was chosen to soften the banana fibre for further processing. The banana fibres were soaked in water and treated by boiling with 5% castor oil and wetting agent in material Liquor ratio 1:20. The treated fibres were rinsed in non ionic soap solution, boiled in water, rinsed in water and dried completely in shade.

The treated banana fibres were spun into two types as hand spun and rotor spun yarn. In hand spinning, 100% banana fibre was spun into a coarser yarn using manual coir spinning machine. Rajput and Khot, (2022) states that banana yarn can be better spun by open-ended spinning process by cutting fibres three cm length and spun. Hence rotor spinning was followed for spinning banana cotton (40: 60 ratio) blended yarn. The softened banana fibres

were cut into small lengths of 2.5 cm and blended with cotton fibres by lap formation in carding machine in Try Tex lab model carding and roving machine. The carded lap was made into a sliver and spun into yarn using a lab model rotor spinning machine in textile production lab, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore.

Phase III: Weaving banana cotton blended fabric

Cotton yarn, 100 per cent banana yarn and banana cotton blended yarn were used for weaving fabrics. Three different types of fabric were woven using banana fibre yarns in handloom and power loom for the study.

Fabric1-Cotton yarn along the warp and the hand-spun 100% banana yarn along the weft.

Fabric 2- Cotton yarn as warp and banana cotton blended yarn as weft.

Fabric 3 - Banana cotton blended yarn on both warp and weft directions.

Pretreatment of Fabrics

The conventional three step pretreatment process consists of desizing, scouring and bleaching (Harane and Adivarekar, 2016). Conventional pretreatment methods can give rise to undesirable reduction of fibre strength, cause environmental contamination and depletion of natural resources. Many efforts have been made in science and technology to develop environmentally friendly processes and alternative materials should be considered (Ali and Karale, 2022). Hence, chemical use for pretreatment was avoided, and eco-friendly substances were used for these processes.

The three woven fabrics, along with procured 100% cotton fabric, were pretreated for further dyeing and printing processes. Desizing, scouring and bleaching processes were carried out as pretreatments. Desizing was carried out by soaking the material in water for 30 minutes, washing, rinsing and boiling in water for thirty minutes and rinsing in soft water. The fabrics were scoured by immersing them in cow dung solution (2 kg/50 litres) and left for 24 hours. Later, it was removed from the solution and rinsed thoroughly several times for further treatment. For the bleaching process, the material was soaked in buttermilk for 24 hours. 100 per cent cotton fabric, banana cotton mixture fabric and Banana blended fabrics were completely immersed in the buttermilk solution for 24 hours. The fabrics were then rinsed thoroughly and dried in sunlight. The pre-treated fabrics and grey fabrics were evaluated for their properties.

Phase IV: Dyeing on Cotton and Banana Cotton blended fabrics

Due to environmental awareness, a reasonable number of researchers have worked on the colouration of textile materials using natural dyes. *Peltophorum pterocarpum*, commonly called Copper pod or Golden Flamboyant, belongs to the Fabaceae family and is an ornamental tree found around the world. Different parts of this tree are used to treat many diseases. The bark of the tree is used for colouring in the textile industry, states Muthukumaran et al., (2016).

Peltophorum pterocarpum flowers and bark were used as dye source for dyeing these fabrics. Extraction of these sources was optimised with extraction medium alkali, time 60 minutes, temperature 90°C. The extracts were used for dyeing fabrics with four mordants myrobolan, pomegranate rinds, tamarind rinds and alum with pre, simultaneous and post mordanting techniques. The dyed fabrics were evaluated for colour strength and colour fastness.

Phase V: Printing on Woven Cotton and Banana Cotton blended Fabrics

Printing was also carried out with dye powder from flower and bark with gum arabic as thickener , four mordants and three mordanting techniques. The printing was carried out using screen printing method on cotton fabric C and Fabric 2 –F2 (C/CB).The printed fabrics were evaluted for colour strength and colour fastness.

Preparation of Table mats was carried out from selected dyed and printed fabrics.

Findings of the Study

Findings of Survey

- The survey was executed among 300 adult women in the age group of 18 - 55 years. Among them 50.7% were homemakers, 34.7% were employed, 8.3% were professionals, and 6.3% were self employed. Regarding preference in texture of fabrics 23.7% preferred soft fabrics, 58.3% preferred medium texture and 7% preferred rough textured fabrics. Regarding prints, 7.7% preferred plain fabrics, 29.7% preferred floral prints, 7.3% preferred small prints, 16.3% preferred abstract designs and 7% preferred geometric whereas as 22.3% preferred using all these prints.
- With regard to preference of branded products 36.3% preferred branded products and 63.7% did not have any preference towards branded products.

- In material type, 27.3% preferred cotton, 16.7% preferred synthetic, 6.7% preferred blends, 6.7% preferred linen, 6% preferred coir, and 6.7% preferred jute and 33.3% preferred to use all types of fabrics.
- With regard to awareness in eco-friendly products 96.7% were aware of eco products, and 89.75% respondents aware of natural dyed fabrics. Around 92% showed interest in using eco-friendly products in home textiles. 85% respondents were interested in using banana fabrics for home textiles.

Evaluation of treated Banana fibres and Spun Banana Yarn

- Evaluation of the treated banana fibres showed, that castor oil treated fibres had handle for spinning into yarn. Single fibre strength of castor oil treated fibres were higher than other treated fibres. The FESEM analysis showed diorientation of fibre surface of all three treated fibres.
- The single yarn tensile strength of 100% hand spun banana yarn was found to have higher strength than blended yarn. However the elongation per cent of hand spun yarn was much lesser than the blended yarn. The statistical analysis of these data showed significance at 1% level.

Evaluation of woven and pretreated fabrics

- Evaluation of fabric count, thickness, weight, stiffness, tensile strength and elongation , absorbency properties and TGA analysis.
- Fabric count of Cotton, F2 and F3 increased by 34%, 30% and 17% respectively after pretreatment while F2 had slight decrease of 4% along warp direction. Similarly fabric count increase in cotton, F2 and F3 and decreased in F1 along weft direction.
- Fabric thickness increased for F1, F2 and F3 with 33.13%, 22.% and 3.68% respectively and decreased by 27.7% for cotton fabric. The fabric weight of all samples increase after pretreatment with 13.53%, 1.99%, 7.97 and 2.63 %.
- Fabric stiffness of all samples decreased after pretreatment both along warp and weft direction.
- Tensile strength and elongation of fabrics increased for sample cotton, F2 and F3 while it decreased for F1 along warp direction. Tensile strength and elongation of all samples increased after pretreatment along weft direction.
- Absorbency properties of all fabrics increased after treatment.

Evaluation of dyed fabrics

- Dye extraction from flower were optimised as 15% concentration for flower and 10% concentration for bark in 60 minute time and 90 °C.
- Phytochemical analysis of extracts showed the presence of the flavonoid , tannins and saponins in flower and alkaloids, flavonoids steroids, terpenoids, proteins, phenolics, glycosides and saponins in bark, which indicates it can be used a dye source.
- The FTIR test indicated presence of functional group which confirms the presence of phytocompounds such as alkaloids, steroids, phenolic, flavonoids, terpenoids, and carbohydrates etc in the aqueous and alkaline extracts of plant.
- Among flower dyed samples Fabric 1- F1 had higher colour strength than other samples
- While comparing among samples of same fabrics post mordanting with pomegranate rinds was found to be good in all samples except Fabric3, with post mordanting with myrobolan and simultaneous mordanting with pomegranate rinds following next respectively.
- Among bark dyed samples Fabric 1-F1 and Fabric 3-F3 had higher colour strength than other samples. Fabric 3 and Fabric1 simultaneous mordanting with alum, and pomegranate rinds had good colour strength.
- In colour fastness tests samples dyed with flower had moderate to fair fastness in sunlight and washing and good fastness to pressing and crocking in general.
- Colour fastness test of bark dyed samples showed moderate to fair fastness in general, while Fabric1 and fabric 3 had good fastness with pomegranate mordanting. Good to very good fastness to pressing and crocking was observed in most samples.

Evaluation of printed fabrics

- In printed samples fabrics printed with bark dye showed higher colour strength than flower printed samples. Mordanting with pomegranate rinds was found to be better than other mordants.
- Colour fastness of printed sample with bark showed poor to moderate fastness to sunlight and for washing moderate to good.
- Banana fabrics can be dyed with *Peltophorum pterocarpum* flowers and bark extracts though printing with these dye sources have poor fastness to washing and sunlight.

Conclusion

• In the present scenario banana cotton mixture and blended fabrics can be used as sustainable textile alternative for conventional natural fibres like cotton.

• Flower and bark extracts of *Peltophorum pterocarpum* could be effectively used for dyeing and printing on cotton and banana cotton blended fabrics.

• This could be a suitable solution in reducing pollution caused due to use of chemicals and synthetic dyes in textile processing and help create employment opportunities and income generation for the rural community.

• The woven banana cotton blended fabric can be used as eco-friendly home textile product like table mats. Large scale production can be cost effective.

Recommendations for further study

- The banana cotton blended fabric can be considered for other home furnishing and technical textiles
- Banana cotton blended fabric can be dyed with various natural sources for vibrant colours and shades.
- Hand printing methods such as block printing can be attempted for printing on banana cotton blended fabric.

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